DIET OF A FAMILY OF POWERFUL OWLS (*NINOX STRENUA*) FROM WARRANDYTE, VICTORIA

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The diet of a family of powerful owls living at Warrandyte State Park was examined by analysis of 631 regurgitated pellets collected over five years (1991 to 1995). Warrandyte State Park forms a riparian strip along the Yarra River and is 24 km north-east of Melbourne. The Park's habitat has been disturbed in the past and it is surrounded by housing, introduced pastures and orchards. Mammalian prey was found in 98%, birds in 2% and insects in 8% of the pellets. Of the mammals, common ringtail possums occurred most frequently in the pellets, with no seasonal differences in occurrence. In contrast, common brushtail possums (which were found in 29% of pellets with mammalian remains) and sugar gliders (7%) showed seasonal variation in occurrence. The majority of common brushtail possums taken as prey were less than one year old, however, 15% were adults. We conclude that powerful owls feed opportunistically on suitable arboreal marsupials including large common brushtail possums, and that at Warrandyte most prey taken are not dependent on hollows for nesting.

THE POWERFUL owl (*Ninox strenua*) is Australia's largest owl. It occurs on the mainland with most populations concentrated on the eastward side of the Great Dividing Range (Blakers et al. 1984), although breeding pairs have been reported well outside of this range (Rolls 1979; Pavey 1993). Historically, *N. strenua* has been considered a habitat specialist, being most numerous in dense gullies of tall, old-growth forests in hilly or mountainous localities of the coast and the Great Divide (Debus & Chafer 1994).

Powerful owls are considered rare at a national scale (Garnett 1992) and also in Victoria (Department of Conservation and Natural Resources, Victoria 1995). In the Greater Melbourne area the owl is considered threatened (Mansergh et al. 1989). However, there have been recent reports of breeding powerful owls in a wide range of habitats, many of which are disturbed (Debus & Chafer 1994; Pavey 1994). Nevertheless, Chafer (1992) has urged comprehensive studies be carried out on the species' diet and habitat requirements in order to resolve questions of its status and to facilitate its conservation management.

Powerful owls are believed to need large home ranges (about 1000 ha per pair) (Schodde & Mason 1980) in suitable old-growth forest which provide nest hollows for the owls and for their arboreal marsupial prey (Fleay 1968; Seebeck 1976; Roberts 1977). Recent studies, however, have suggested the species is more flexible in its habitat requirements. For example, Quinn (1993) has reported two breeding pairs of owls less than 400 m apart. In central coastal New South Wales, Chafer (1992) found the species in more locations, in a wider variety of forest types and roost sites and nesting at lower heights than previously recorded. Other studies (e.g. Debus & Chafer 1994; Kavanagh et al. 1995) have found the owls are little affected by habitat modification other than clear-felling and conversion to open landscape. For instance, Kavanagh and Bamkin (1995) have reported *N. strenua* in equal frequencies in unlogged forests and in logged and unlogged mosaics with dispersed coupes. Other reports further suggest that powerful owls can breed and raise young in sites that are affected by human activity, such as urban parks (Pavey 1993, 1995; Chafer 1992), a disturbed forest park (Quinn 1993) and a caravan park (McNabb 1994).

Previous studies have shown that the owls feed mainly on those medium-sized species of arboreal marsupials that are most readily available at a given site, such as common ringtail possums (*Pseudocheirus peregrinus*) (Seebeck 1976; Tilley 1982; Hollands 1991; Chafer 1992; Traill 1993; Lavazanian et al. 1994; McNabb 1996) and greater gliders (*Petauroides volans*) (Fleay 1968; Kavanagh 1988). Pavey (1992), however, disputes the importance of greater gliders in the diet of the

powerful owl which several authors have claimed, for example Tilley (1982) and Kavanagh (1988). There is thus debate in the literature as to whether powerful owls specialise their foraging activities to obtain prey species such as greater gliders in accordance with optimal foraging theory (Kavanagh 1988; Pavey 1992). There is also a question as to whether dietary specialisation on hollow-dependent arboreal marsupials renders the powerful owl vulnerable to habitat disturbance (Debus & Chafer 1994; Lavazanian et al. 1994).

Other possums and gliders, fruit bats, birds and insects are also taken depending on their availability (Tilley 1982; Chafer 1992; Pavey 1994; Pavey et al. 1994; Pavey 1995). The common brushtail possum (*Trichosurus vulpecula*) has been recorded as prey of the powerful owl by numerous authors (e.g. Van Dyck & Gibbons 1980; Debus & Chafer 1994; Lavazanian et al. 1994; Pavey et al. 1994). This species has a major peak in births between March and May and a smaller peak in September and October (Kerle 1984). Common brushtail possum remains in powerful owl pellets have been found by Van Dyck & Gibbons (1980) almost exclusively in spring, suggesting that only juveniles are taken, probably when riding on their mothers' backs. Little evidence is available to indicate that adult common brushtail possums, which weigh up to 4.5 kg (Strahan 1995), are taken as prey by the powerful owl. Adult brushtail possums can weigh more than twice as much as adult powerful owls and thus could be considered a difficult prey item for owls.

In 1990 a breeding pair of powerful owls was located in Warrandyte State Park, an urban, riparian park which is only 24 km from central Melbourne and which fringes the Yarra River. The aims of this study are to describe the seasonal variation in the diet of the owls, and also to determine the ages of common brushtail possums taken as prey.

METHODS

Warrandyte State Park is a 586 ha reserve 24 km north-east of Melbourne. The park is a linear strip of mainly riparian forest dominated by eucalypts (especially *Eucalyptus polyanthemos* and *E. viminalis*) with an understorey of wattles and tall shrubs. The park is positioned at the transition between the suburbs of Melbourne and the more rural setting of the Upper Yarra Valley. There are nearby steeply forested slopes (east of Wonga Park) and forest patches alongside tributaries (e.g. Mullum Mullum Creek) or in small blocks (e.g. Currawong Bush Park) (Department of Conservation and Environment, 1990). However, the park is mostly surrounded by housing, some pasture and orchards.

The park has been subjected to frequent fuel reduction fires and also wildfires. For instance, since 1857 there have been 11 major wildfires recorded (the most recent of which was in 1969), 16 fuel reduction burns and 11 accidentally started spot fires (Department of Conservation and Environment, 1990).

A total of 631 regurgitated food pellets were collected between 1991 and 1995 from roost sites used by a pair of owls and their young. The owls have been seen in 40 roost trees from seven locations in the Park (Table 1). Six of the locations were adjacent to the Yarra River and the other was 1.5 km from the river.

Pellets were placed in envelopes marked with location and date and sterilised at 100°C for 24 h. Prey items were categorised into major food types and the mammalian prey remains were then separated into skeletal and hair components. A diagnostic aid was developed to help identify mammalian remains. This key contained photographs of bones of the three main mammalian prey species and highlighted the distinguishing characteristics of each species. The principal skeletal parts used were skull (including lower jaw and teeth), humerus, femur, pelvic girdle and scapula. Further details of the diagnostic aid are to be found in Lavazanian (1996) and Cooke (1995). Brunner & Coman (1974) was used to help distinguish between primary guard hairs of the three species.

Skeletal remains of common brushtail possums were categorised into three age classes: juvenile (<1 year old), immature (1–4 years) and adult (>4 years) on the basis of fusion of epiphyses (Kingsmill 1962), shape and size of limb-bones, shape and size of pelvic girdles, skull size, extent of sagittal crest and eruption of teeth (Cooke 1995).

Species	Number
Red box (*Eucalyptus polyanthemos*)	12
Willow (*Salix* spp.)	6
Wattles (*Acacia* spp.)	8
Messmate (*E. obliqua*)	3
Tea-tree (*Leptospermum* spp.)	3
Manna gum (*E. viminalis*)	2
Cherry ballart (*Exocarpos cupressiformis*)	2
Unidentified eucalypt sapling	1
Hazel pomaderris (*Pomaderris aspera*)	1
Christmas bush (*Prostantha lasianthos*)	1
Burgan (*Kunzea ericoides*)	1

Table 1. Roost trees used by powerful owls at Warrandyte State Park.

RESULTS

More pellets were collected during spring (September–November) than the other seasons. During spring the young owls have emerged from the nest and roost with their parents. The parents are more easy to detect in spring than in other seasons because they remain close to the young. In autumn the juvenile owls fledge and probably leave the parents' home range and the parents often roost separately which makes them more difficult to locate. As well, in winter when the owls roost at times over the river, pellets are not always retrievable. Consequently, fewer pellets were collected in autumn and winter than the other seasons.

Mammals occurred in 98% of the pellets (Table 2). The five pellets without mammals contained bird remains. Insects occurred in 8% of pellets and most frequently during summer and autumn.

The numbers of pellets containing each of the six mammalian prey species identified for each season is given in Table 3. Common ringtail possums were the most frequent prey item (in 64% of pellets with mammalian remains) although common brushtail possums were also commonly detected (29%). There was no difference across the four seasons in the proportion of pellets containing common ringtail possum (Chi-square test, $P>0.05$) although there were significant seasonal differences in proportional occurrences of the common brushtail possum ($P<0.005$) and sugar glider (*Petaurus breviceps*) ($P<0.05$).

Most of the pellets with brushtail possum remains contained juvenile possums (63%) (Table 4), and most of these were collected during spring. However, 26 pellets (15%) also contained the remains of adult brushtail possums.

DISCUSSION

Other studies we are carrying out suggest there are now likely to be at least five pairs of powerful owls living in an area of 10 000 ha in the Yarra

Food item	Summer	Autumn	Winter	Spring	Total
Mammals	146 (100)	99 (100)	108 (98)	273 (98)	626 (98)
Birds	6 (4)	2 (2)	2 (2)	1 (1)	11 (2)
Insects	34 (23)	15 (15)	1 (1)	3 (2)	53 (8)
Total no. of pellets	146	99	110	276	631

Table 2. Dietary components as the number of pellets in which a prey category was represented of owl pellets collected in each of the four seasons. Values in parentheses are percentages of the number of pellets examined for that season.

Mammalian prey	Summer	Autumn	Winter	Spring	Total
Common ringtail possum (*Pseudocheirus peregrinus*)	106	75	70	149	400 (64)
Common brushtail possum (*Trichosurus vulpecula*)	29	14	31	110	184 (29)
Sugar glider (*Petaurus breviceps*)	12	12	0	21	45 (7)
Yellow-bellied glider (*Petaurus australis*)	0	0	0	2	2 (0.3)
Rabbit (*Oryctolagus cuniculus*)	0	0	0	3	3 (0.4)
Cat (*Felis catus*)	0	0	0	1	1 (0.4)
Unidentifiable	1	0	7	3	11 (1.5)
Total no. pellets	146	99	108	273	626

Table 3. Number of pellets containing mammalian prey for each season. Values in parentheses are percentages of pellets with that species of the 626 pellets known to have mammalian remains.

Age class	Summer	Autumn	Winter	Spring	Total
Adult (>4 years)	4	4	7	11	26 (15)
Immature (1–4 years)	5	3	9	19	36 (22)
Juvenile (<1 year)	16	5	10	73	104 (63)

Table 4. Age classes (remains in 166 pellets) of common brushtail possums taken over the four seasons. Values in parentheses are percentages of possums taken from that age class.

Valley. This habitat is severely fragmented and disturbed by human activities. A recent sighting of a pair of owls which failed to rear young at a site downstream from Warrandyte State Park suggests the owls are expanding in range, certainly into habitats which differ from the dense gullies of tall, old-growth forest in which the species was historically thought to be restricted. These recent sightings support the belief of Debus & Chafer (1994) that the species has wider habitat tolerance than formerly believed and also the findings of Pavey et al. (1994) who studied the owls around Brisbane.

Our data also support dietary studies conducted elsewhere that have found common ringtail possums to be the principal prey species in coastal or lowland sites in Victoria (Seebeck 1976; Tilley 1982; Hollands 1991; Lavazanian et al. 1994). As expected, the diet of the Warrandyte owls is similar to that of a pair of powerful owls at Christmas Hills which is only 15 km north-east of Warrandyte State Park (Lavazanian et al. 1994). Important differences were, however, that fewer birds were found in pellets from the Warrandyte birds (2% occurrence compared with 10% Christmas Hills) and common brushtail possum remains were more frequently detected in pellets of the Warrandyte birds (29% of pellets with mammals compared with 3%). Preliminary spotlighting data suggest that high densities of common ringtail possums live in the Park. Thus Cooke (1995) carried out 17 h of spotlighting over three seasons and 184 possums were observed, of which 162 were ringtail and 22 brushtail possums. However, a survey of local residents indicates brushtail possums are common in properties adjacent to the Park and that many of these possums live in the roofs of homes (Cooke 1995). Another interesting difference concerns the use of hollows and dreys by common ringtail possums. At Christmas Hills most ringtail possums nest in tree hollows and dreys are rarely seen. As well, sugar gliders and the few common brushtail possums detected in Lavazanian's (1996) spotlighting surveys also occupy tree hollows. In contrast, common ringtail possum dreys are very common in Warrandyte State Park and there appears to be a shortage of tree hollows suitable for nesting possums.

Most common brushtail possums were detected in pellets collected during spring. This is consistent with findings reported elsewhere by Seebeck (1976), Tilley (1982), Van Dyck & Gibbons (1980) and Lavazanian et al. (1994) and is believed to be related to the emergence of young common brushtail possums on to their mothers' backs.

Common brushtail possums are polyoestrous and monovular and give birth to a single young at each parturition (Smith et al. 1969). There is a distinct peak in births between March and May and a lesser peak in September and October (Kerle 1984). The young possums emerge from the pouch four to five months after birth and remain close to their mother, often riding on her back. This can explain the peak in predation of common brushtail possums by the owls in spring and to a lesser extent in autumn. The presence of ten pellets collected during winter with juvenile brushtail possums remains can be explained by collections occurring in early winter. The pellets had been present for some time and were possibly regurgitated during autumn (A. Webster, unpublished data).

Ninety per cent of common brushtail possum remains in pellets could be categorised into age classes (Table 4). The majority (63%) of brushtails taken as prey were less than one year old. Nevertheless, 15% of the remains of brushtail possums taken were classed as older than four years, indicating that powerful owls do indeed take adult common brushtail possums as prey. This observation is noteworthy because of the large size of adult common brushtail possums (adult weight range of possums collected in Melbourne 5.0–3.0 kg; RSPCA, unpublished data). In contrast, Lavazanian et al. (1994) found 50% of common ringtail possums (in which maximum mass is only one quarter that of the brushtail possum) taken by powerful owls at Christmas Hills were adults.

Although it is uncommon for owls to take prey heavier than themselves (Braithwaite 1996), Mooney (1993) reported that masked owls (*Tyto novaehollandiae*) in Tasmania took prey up to two and a half times their own weight, a similar ratio

was observed in our study for powerful owls consuming adult common brushtail possums.

The presence of yellow-bellied gliders (*Petaurus australis*) in two pellets is interesting. Although it has been reported in the diet of powerful owls elsewhere (Debus & Chafer 1994), the yellow-bellied glider is not taken as a major food item even when they are present in the area (Tilley 1982; Kavanagh 1988). Also, yellow-bellied gliders are unknown in Warrandyte State Park, the nearest known location being 17 km away in Kinglake National Park.

Rabbit remains were detected in three pellets. This is unusual as rabbits do not climb trees and powerful owls are believed to mainly take arboreal prey. However, Lavazanian et al. (1994) found rabbit remains in 0.5% of pellets from Christmas Hills, and hares have been reported in powerful owl pellets by Chafer (1992) in New South Wales and by Pavey (1994) in Queensland. Even more unusual was the occurrence of cat fur in one pellet we found, although Chafer (1992) found two individual cat remains (out of 56 prey items) from pellets collected at Bass Point, south of Wollongong.

Our data suggest powerful owls are opportunistic in that they take those arboreal prey which are easiest to obtain, including adult common brushtail possums which are more common at Warrandyte than at nearby Christmas Hills (Lavazanian et al. 1994). As well, this study casts doubt on the conclusion that the future conservation of the owl is dependent on the continued availability of hollow-dependent marsupial prey; most prey taken nested in dreys (common ringtail possums) or in artificial structures such as house roofs (common brushtail possums).

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